Title

Risk factors for human-directed aggression in a referral level clinical population

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Abstract

Risk factors for human-directed aggression were investigated using retrospective analysis of data from a referral level clinical behaviour population in the UK. A sample of 200 cases involving human-directed canine aggression and 200 control cases involving no instance of human-directed aggression were selected at random from a population of 746 cases. The final model suggested that clinical cases with human directed aggression were significantly younger than those presenting with other undesired behaviours (P = 0.008) and that male dogs were 1.4 times more likely to be aggressive towards humans than female dogs (P = 0.019). Dogs were 1.7 times more likely to be aggressive towards people if they had attended more than five puppy classes than if they had never attended puppy class (P = 0.015) and that dogs were 2.8 times more likely to be aggressive towards humans if there was another dog between 0 and 24 months of age in the home (P = 0.004). These factors only account for 7 – 10% of the variance between the human-directed aggression population and the control population, but factors such as attendance at puppy classes and numbers of dogs in the household suggest the need for longitudinal studies to investigate temporal relationships.

Introduction

Recent changes in dog laws in the UK reflect a growing concern regarding public health and animal welfare consequences of canine aggression. A dog is

considered 'dangerously out of control' if it injures or attacks a person or their animal, or if a person is concerned that it may injure them or that they may be injured if they tried to stop the dog attacking their animal (UK[1]). This law extends to any incidents in public places, private places and the owner's home. Aggression is defined as growling, snarling, lunging, snapping, biting and/or threatening barking (Mertens 2002) and is the most frequent reason for dog relinquishment (Salman et al. 1998; O'Sullivan et al. 2008a; Kim et al. 2009) and for referral to canine behaviourists (Blackshaw 1991; Beaver, 1999; Landsberg et al. 2003, Bamberger and Houpt 2006). Human directed aggression is a serious public health issue (Weiss et al. 1998; Chen et al. 2000; Calkins et al. 2001), and is suggested to constitute 54% - 67% of all aggression reported to veterinary behaviourists in the US (Beaver 1999). In Western societies such as the USA and the Netherlands, the frequency of dog bites ranges from 8 – 18 incidences per 1,000 people (Sacks et al. 2000; Overall and Love 2001; Gilchrist et al. 2008; Cornelissen and Hopster 2010; Casey et al. 2013). According to Michaelazzi et al. (2004) both the frequency and severity of reported dog bites is increasing, as is the level of public concern (Horisberger et al. 2004). However, these frequencies are estimates and may be subject to a degree of error given the methodologies and populations from which they are generated.

Studies have variably used hospital recorded bite victims (e.g. De Keuster et al., 2006); specialist behaviour clinical populations (e.g. Fatjó et al., 2007); first opinion veterinary practice populations (e.g. Guy et al., 2001a); temperament screening for particular populations or breeds of dogs (e.g. Ott et al., 2008), and surveys of dog owners (e.g. Hsu and Sun, 2010). Many of these populations have inherent biases. For example, large breed dogs are more likely to cause injuries to children requiring hospital treatment (Overall and Love, 2001), and incidences with owned dogs have been reported to be less likely to be associated with injuries requiring medical attention than those occurring in public places (Cornelissen and Hopster, 2010). Hospital-based studies investigating dog bite occurrence often describe the type of injury recorded (Morgan and Palmer 2007), age and sex of the victim (Sacks et al. 1996; Weiss et al. 1998), and breed/type of dog (Kaskebar et al. 2013; Pfortmueller et al. 2013). However

information regarding the behaviours of the dog and the human leading up to the incident is rarely included, and when it is, it is often not feasible to perform any significant analysis on this information (Overall and Love 2001). The potential biases and interpretational problems of these datasets are reviewed further elsewhere (Casey et al. 2013; Newman 2012)

Whilst many studies provide useful insights into the factors affecting aggression in dogs, it is important to recognise that many have utilised populations with inherent biases, are not longitundal or do not have controls for comparison. By virtue of their design findings of these studies are unlikely to determine causal associations (Cornelissen and Hopster 2010; Newman 2012). Problems of interpretation can also occur where studies have used multiple univariate analyses in examining the relationship between occurrence of aggression and either intrinsic or environmental factors (Bender and Lange 2001). For example, where potential interactions are not investigated, and the risk of confounding factors and multiplicity problems may not be accounted for (Pocock 1997; Bender and Lange 2001), resulting in potentially misleading outcomes (Hsu and Sun 2010). Multivariate analyses have the advantage of reducing the risk of over-interpretation of individual risk factors on aggression occurrence (Guy et al. 2001a; Bennett and Rohlf 2007; Messam et al. 2008; O'Sullivan et al. 2008b).

Various dog characteristics have been reported as associated with occurrence of human-directed aggressive behaviour, including; sex and neuter status (Borchelt 1983; Gershman et al. 1994; Goodloe and Borchelt 1998; Amat et al. 2009; Cameron 1997; Takeuchi and Houpt 2003), breed (legislations enacted by jurisdictions in the UK[1], Ireland[2] and Germany[3]) and health of dog (Guy et al. 2001b).

Other risk factors for human-directed canine aggression include; number of children in the home (Gershman et al. 1994), age of child (Kasbekar et al. 2013, though see Gilchrist et al. (2013) where authors suggests rates of aggression are decreasing based on their hospital-based study) number of teenagers in the

home (Guy et al 2001b), training method used by owner (Casey et al. 2014), and allowing the dog to sleep in the bed with owner (Guy et al. 2001b).

In this retrospective study, we used a multivariable approach to investigate the influence of dog and owner characteristics, dog experiential information and environmental risk factors for human-directed canine aggression as compared to a referral population of other behavioural representations.

Materials and methods

2.1 Data collection

Data from dogs with abnormal or undesirable behaviour patterns in this study came from the caseload of one veterinary school clinical behaviour referral centre in the UK. The study population was 746 referred canine behaviour cases that were seen between Jan 2003 and December 2013. A sample of 200 cases involving human directed canine aggression was selected at random from those where owners reported aggression as a presenting complaint. Cases were retained in the aggression group where a diagnosis of aggression was confirmed by the clinician in the post-consultation report. . A sample of 200 control cases was selected from the remainder of cases referred to the same clinic, excluding any where human-directed aggression was reported. Control cases included those involving dog/cat directed aggression, as long as no human directed aggression was exhibited also. Aggression was defined as growling, snarling, lunging, snapping, biting and/or threatening barking (Mertens 2002).

Data from each case came from a standard questionnaire filled in by owners prior to the consultation, and the post-consultation clinician report to clients and referring vets. The questionnaire included sections on dogs' signalment, early experiences, diet, exercise routine, household situation, training history, family situation, medical history and categorization of any other behaviour problems shown by the dog. Variables selected for analysis were based on *a priori* evidence or biological rationale, and are shown in Table 1.

2.2 Statistical Analyses

Data was analyzed using SPSS (Statistical Package for the Social Sciences, Version 12 for Windows). The dependent variable for analysis was the presence or absence of human directed aggression. Explanatory variables were initially described using frequencies for categorical variables and mean, SD and range for dog age. Categories were combined where they both occurred at low frequency and combination was plausible. Explanatory variables were initially screened using univariable logistic regression models. Variables with a Wald test p-value of less than or equal to 0.2 in this screening were included in multivariable model building. The multivariable model was built using a backward stepwise approach, where the effect of removing each variable on model fit and deviance was assessed at each stage. Variables were removed until only those with a Wald test p-value of <0.05 remained. The final model was assessed using the Hosmer-Lemeshow Test (Hosmer and Lemeshow 1989) for goodness of fit.

Results

3.1 Study Population Characteristics

Of the 747 dog cases seen at the referral centre, 502 (67.3%) involved at least one form of canine aggression and a mean of 2.1 behaviour problems per dog was established. Within the 200 cases involving human-directed aggression, the mean number of behaviour problems per dog was 1.8 and within the 200 control cases involving no instances of human-direction aggression, the mean number of behaviour problems per dog was 1.6.

Table 1 summarises the characteristics of dogs in the human-directed aggression (DHA; N=200) and control (N=200) groups. The percentage of males in the DHA population was 73.5% (ratio of 158:57; male to female), and in the control population was 64.8% (ratio of 129:70; male to female). The average age of dogs in the DHA population was 38.8 months of age, (range 4 – 144; standard deviation +/- 30.0) and 47.3 months of age (range 4 – 192; standard deviation +/- 33.7) in the control population.

Table 1. Population characteristics

		Total Pop		DHA Pop		Non-DHA Pop	
Characteristic	Categories	n	(%)	n	(%)	n	(%)
Dog gender	Males	287	(69.3)	158	(73.5)	129	(64.8)
	Females	127	(30.7)	57	(26.5)	70	(35.2)
Dog neuter status	Entire	115	(27.8)	60	(27.9)	55	(27.6)
	Neutered	299	(72.2)	155	(72.1)	144	(72.4)
Dog gender *and* neuter status	Male entire	76	(18.4)	40	(18.6)	36	(18.1)
	Female entire	39	(9.4)	20	(9.3)	19	(9.5)
	Male Neutered	211	(51)	118	(54.9)	93	(46.7)
	Female Neutered	88	(21.3)	37	(17.2)	51	(25.6)
Dog grouping by UK Kennel Club categories	Cross	99	(23.9)	55	(25.6)	44	(22.1)
	Gundog	94	(22.7)	42	(19.5)	52	(26.1)
	Pastoral	67	(16.2)	36	(16.7)	31	(15.6)
	Terrier	68	(16.4)	36	(16.7)	32	(16.1)
	Utility	20	(4.8)	13	(6.0)	7	(3.5)
	Working	29	(7)	13	(6.0)	16	(8.0)
	Hounds	18	(4.3)	12	(5.6)	6	(3.0)
	Toys	19	(4.6)	8	(3.7)	11	(5.5)
Adults in the home	1	47	(11.4)	21	(9.8)	26	(13.1)
	2	288	(69.6)	147	(68.4)	141	(70.9)
	3+	79	(19.1)	47	(21.9)	32	(16.1)
Children in the home	None	217	(52.4)	100	(46.5)	117	(58.8)

	One child aged 0 - 2	28	(6.8)	16	(7.4)	12	(6.0)
	Children aged 0 - 2	4	(1)	2	(0.9)	2	(1.0)
	One child aged 3 - 12	50	(12.1)	29	(13.5)	21	(10.6)
	Children aged 3 - 12	41	(9.9)	24	(11.2)	17	(8.5)
	One child aged 13 - 18	47	(11.4)	29	(13.5)	18	(9.0)
	Children aged 13 – 18	27	(6.5)	15	(7.0)	12	(6.0)
	Children aged 0 – 12	115	(27.8)	66	(30.7)	49	(24.6)
	Children aged 3 – 17	135	(32.6)	78	(36.3)	57	(28.6)
	Children aged 0 - 17	159	(38.4)	91	(42.3)	68	(34.2)
Other dogs in the home	None	271	(65.5)	154	(71.6)	117	(58.8)
	One other dog	116	(28)	51	(23.7)	65	(32.7)
	More than one other dog	27	(6.5)	9	(4.2)	18	(9.0)
Sex of other dogs in the home	No other dogs	272	(65.7)	154	(71.6)	118	(59.3)
	Male(s) only	56	(13.5)	28	(13.0)	28	(14.1)
	Female(s) only	72	(17.4)	30	(14.0)	42	(21.1)
	Both sexes	14	(3.4)	3	(1.4)	11	(5.5)
Age of other dogs in the home	No other dogs	272	(65.7)	154	(71.6)	118	(59.3)
	Other dog(s) is 0 – 6 months	6	(1.4)	1	(0.5)	5	(2.5)
	Other dog(s) is 7 – 24 months	40	(9.7)	14	(6.5)	26	(13.1)
	Other dog is 25 – 96 months	59	(14.3)	29	(13.5)	30	(15.1)
	Other dogs is 97+ months	37	(8.9)	16	(7.4)	21	(10.6)
Other animals in the home	No other animals	261	(63)	138	(64.2)	123	(61.8)
	Cat(s)	92	(22.2)	41	(19.1)	51	(25.6)

	Small prey	35	(8.5)	21	(9.8)	14	(7.0)
	Horses/sheep	7	(1.7)	2	(0.9)	5	(2.5)
	Cat(s) and small prey	14	(3.4)	9	(4.2)	5	(2.5)
	Small prey and horses/sheep	4	(1)	3	(1.4)	1	(0.5)
	Cat(s) and horses/sheep	1	(0.2)	1	(0.5)	0	(0.0)
Exercise on lead (minutes/day)	None	120	(29)	61	(28.4)	59	(29.6)
	1 – 30	106	(25.6)	58	(27.0)	48	(24.1)
	31 – 60	129	(31.2)	68	(31.6)	61	(30.7)
	61 – 120	54	(13)	25	(11.6)	29	(14.6)
	121+	5	(1.2)	3	(1.4)	2	(1.0)
Exercise off lead (excluding garden) (minutes/day)	None	119	(28.7)	58	(27.0)	61	(30.7)
	1 – 30	85	(20.5)	51	(23.7)	34	(17.1)
	31 – 60	131	(31.6)	58	(27.0)	73	(36.7)
	61 – 120	63	(15.2)	39	(18.1)	24	(12.1)
	121+	16	(3.9)	9	(4.2)	7	(3.5)
Access to garden for >2hours a day	No	196	(47.3)	111	(51.6)	85	(42.7)
	Yes	218	(52.7)	104	(48.4)	114	(57.3)
Attendance at puppy class	Not attended	201	(48.6)	88	(40.9)	113	(56.8)
	Attended one class	11	(2.7)	7	(3.3)	4	(2.0)
	Attended 2 – 5 classes	10	(2.4)	6	(2.8)	4	(2.0)
	Attended more than 5 classes	192	(46.4)	114	(53.0)	78	(39.2)

Attendance at adult training class	Not attended	321	(77.5)	172	(80.0)	149	(74.9)
	Attended one class	6	(1.4)	3	(1.4)	3	(1.5)
	Attended 2 – 5 classes	6	(1.4)	2	(0.9)	4	(2.0)
	Attended more than 5 classes	81	(19.6)	38	(17.7)	43	(21.6)
Any other training (e.g. fly ball, agility etc.)	No	358	(86.5)	186	(86.5)	172	(86.4)
	Yes	56	(13.5)	29	(13.5)	27	(13.6)
Training technique for sitting	PR/NP	318	(76.8)	164	(76.3)	154	(77.4)
	PP/NR	6	(1.4)	3	(1.4)	3	(1.5)
	Other	90	(21.7)	48	(22.3)	42	(21.1)
Training technique for house training	PR/NP	279	(67.4)	151	(70.2)	128	(64.3)
	PP/NR	0	(0)	0	(0.0)	0	(0.0)
	Other	135	(32.6)	64	(29.8)	71	(35.7)

Note:
DHA Pop = population of dogs with human-directed aggression
Control = population of dogs with other behaviour issues
PR/NP = positive reinforcement/negative punishment
PP/NR = positive punishment/negative reinforcement

3.2 Logistic regression

Univariable screening suggested that neuter status, breed type, exercise on lead, amount of exercise off lead per day, attendance at adult training classes, attendance at any other training class, method used to train the dog to sit on command, training technique used to housetrain the dog, number of adults and/or children at home and presence of other animals in the house, had limited influence on the likelihood of human directed canine aggression (P>0.2) and were excluded from further analysis.

The following variables were included in the model building process: age of dog, gender of dog, gender x neuter status, access to garden, attendance at puppy class, sex of other dogs in the home and age of other dogs in the home.

The final model was significant (Chi square = 28.453, *P* = 0.000) (Table 2) suggesting that clinical cases with human directed aggression were significantly younger than those presenting with other undesired behaviours (*P* = 0.008) and that male dogs were 1.4 times more likely to be aggressive towards humans than female dogs (*P* = 0.019). Dogs were 1.7 times more likely to be aggressive towards people if they had attended more than five puppy classes than if they had never attended puppy class (*P* = 0.015) and that dogs were 2.8 times more likely to be aggressive towards humans if there was another dog between 0 and 24 months of age in the home (*P* = 0.004). The Hosmer and Lemeshow Test was non-significant suggesting a good fit. However, the model overall only explained between 7 – 10% of the variance between human directed aggression and non-aggressive dogs in this population (Cox &Snell R Square = 0.069, Nagelkerke R Square = 0.092).

Table 2

Variables remaining in the final multivariable regression model for human directed canine aggression cases

Variable	**Categories**	**Wald Statistic**	**P value**	**Odds ratio (ExpB)**	**95% CI for ExpB**	
					Lower	**Upper**
Age in months		7.000	.008	.991	.985	.998
Dog Gender	Reference category: Male	5.487	.019	.586	.374	.916
	Female					
Attendance at puppy training class	Reference Category: No class	6.354	.042			
	Attended 1 - 5 classes	1.405	.236	1.788	.684	4.672
	Attended more than 5 classes	5.875	.015	1.689	1.105	2.580
Age of other dogs in the home	No other dogs	8.260	.013			
	Other dog(s) is 0 – 24 months	8.298	.004	.355	.176	.718
	Other dog(s) is 25+ months	1.105	..293	.769	.471	1.255

Categories significantly different from reference at P < 0.05

Variables included in the multivariate logistic regression model were: dog age, gender, gender x neuter status, access to garden, attendance at puppy class, sex of other dog(s) in the home, and age of other dog(s) in the home.

Discussion

The proportion of the referred population that presented with DHA was similar to the findings in the APBC annual review of cases (2012) where 65% of canine behavioural problems involved aggression and an average of 1.8 behaviour problems per dog were diagnosed. The behaviour problems included; human-directed aggression, dog-directed aggression, separation related behaviours, noise sensitivities, and abnormal repetitive behaviours. Similarly, Fatjó et al. (2007) found 1.4 diagnoses per dog and Bamberger and Houpt (2006) reported an average of 1.6 diagnoses per dog. Amongst the referral population in this study, the most common form of aggression was human-directed (48%; 358 cases). This supports evidence from many other studies that have found that human-directed aggression is the most common behaviour problem reported in referred/veterinary populations (78%: Askew 1996; 79.4%: Borchelt and Voith

1996; 72%: Bamberger and Houpt 2006; 65% Fatjó et al. 2007, although see Fatjó et al (2006) for contrasting results). Owner surveys suggest that human-directed aggression is lower than dog-directed aggression (Casey et al. 2012), reflecting a difference between what people seek help for and what behaviours actually occur. It is likely that dog owners are more likely to seek help for aggression problems due to the health and safety consequences of this behaviour. This is supported in findings by Lund et al. (1996), which show that if the counselling service was free of charge, aggression was reported as the problem behaviour less frequently than it is in behaviour services with a consultation fee.

There is a trend in some studies for male dogs to be reported as more aggressive than female dogs, (e.g. Borchelt 1983; Fatjó et al. 2007; Pérez-Guisado and Muñoz-Serrano 2009; although univariable analysis was used in these studies). Guy et al. (2001a, 2001b, 2001c) found aggression in males to be context dependent. Their survey showed male dogs to be more likely to have shown growling or possessive aggression before 1 year of age in a multivariable analysis (Guy et al. 2001a), female dogs to be more likely than male dogs to bite at least one family member, particularly smaller females (Guy et al. 2001b; multivariate analysis), and male dogs to be more likely to be dominance-biters (Guy et al. 2001c; univariate analysis). The gender distribution in the human-directed aggression population of this study was 69.5% male dogs and 30.5% female dogs, with multivariate analysis showing males to be 1.4 times more likely to be aggressive towards humans than females. The authors are unaware of any publications to date pertaining to the gender distribution of dogs in the UK dog population though we recognise that further investigation would be beneficial to rule out a population bias to this effect.

Increased aggression in entire male dogs has been suggested to be linked to testosterone effects on behaviour (Borchelt 1983; Wright and Nesselrote 1987; Overall 1997). Casey et al. (2013) reported a lower risk of aggression in neutered females than other categories. In this study, neuter status did not affect the likelihood of human directed aggression in dogs. This finding is consistent

with other studies (van den Berg et al. 2006; Bennett and Rohlf 2007; Hsu and Sun 2010) but contrasts with mixed results from other reports of both lower aggression in neutered dogs (Borchelt 1983; Wright 1990; Gershman et al 1994; Messam et al. 2008), and higher aggression in neutered dogs (Podberscek and Serpell 1997a, 1997b; Guy et al. 2001a). That males were more likely to show human-directed aggressive behaviours in this study, yet entire males had no greater risk than neutered ones, may be related to testosterone 'priming' of the brain in young animals, or because some male dogs may have been neutered because of aggression and/or medical reasons. Longitudinal studies are needed to further investigate the link between neutering and risk of undesired behaviours in dogs.

Associations between breed type and aggression risk have been variable in past studies (Takeuchi and Houpt 2003; Reisner et al. 2005; Svartberg 2006; Rosado et al. 2007; Duffy et al. 2008; Hsu and Sun 2010; Casey et al. 2013), however there was no evidence of breed specific differences in aggression toward humans in this study. It is possible that evidence of breed-related factors are affected by the distribution of preferred breeds as influenced by geographic and cultural differences (Landsberg 1991; Bamberger and Houpt 2006). Data from studies referring only to those owners seeking specialist help may not be indicative of the presence of aggression in a more extensive canine population if they are biased towards particular breeds/types (Fatjó et al. 2007).

Human-directed aggression cases were more likely to be younger than cases presenting with other behavioural issues. Other studies have found aggression to be most likely to occur at 3 – 4 years of age (Bamberger and Houpt 2006; Fatjó et al. 2007), and one study found half of biting dogs to be less than two years of age (O'Sullivan et al. 2008a). Conversely, surveys carried out by Bennett and Rohlf (2007), Hsu and Sun (2010) and Casey et al. (2013), showed an increase in aggression risk with age of dog. Differences could relate to variation in study methodologies and analysis, but may also reflect the cumulative chance of aggression occurring due to increased exposure and reinforcement of behaviour over time (Casey et al. 2013). Given that the present study and the studies

aforementioned are all clinical populations, it is possible that the owners may have sought help for this issue before it deteriorated further with increasing age of dog.

Previous studies have shown owner characteristics such as gender, age, experience and even education to be closely related to dog aggression (Pérez-Guisado and Muñoz-Serrano 2009; Podberscek and Serpell 1997a; Jagoe and Serpell 1996), however Bennett and Rohlf (2007) and Hsu and Sun (2010) concluded that owner's gender, age and experience with dogs did not significantly affect the dog's likelihood to show aggression. This evidence is supported by findings in this study, which showed the numbers of adults, and children in the house also had no effect on the occurrence of aggression. The differences reported in these findings may be attributed to methodological differences between studies (Blackwell et al. 2008), and/or to an "anthropomorphic" attitude wherein owners incorrectly decipher the cognitive abilities of their pets (Bradshaw and Casey 2007). This study did show dogs were more likely to be aggressive towards humans if there was another dog between 0 and 24 months of age in home. It is possible that the increased likelihood of human-directed aggression compared to other behaviour problems seen in this study, when there is another adult dog in the home, is due to the cumulative effect of there being more than one dog in the household, thus increasing the probability of human-directed aggression. Another possibility is that the presence of another dog in the household leads to more dog-focused than human-focused interactions, and as such may contribute to a lack of socialisation and potential increased likelihood of aggression towards humans.

In this study, attendance at adult training classes or other classes such as flyball and agility had no association with the likelihood of human-directed canine aggression. However, dogs were more likely to show human directed aggression if they attended more than 5 puppy classes compared to not attending any or attending 1 – 5 classes. As the causality of this relationship cannot be ascertained from these data, it may be either that; owners continued to attend classes with dogs if they were having problems with them, puppies showed

aggression at an early age, or owners were inexperienced at handling or training their dog. It may also be that the training methods used in some classes influence this association.

Punishment based training techniques are often associated with the development of undesirable behaviour (Hilby et al. 2004; Blackwell et al. 2008; Herron et al. 2009). However, the direction of causality in this relationship should also be addressed to determine if aggression is induced by aversive handling methods or whether owners are more likely to rely on confrontational methods if their dog is displaying aggressive tendencies. In this study, only the training techniques for sitting and for housetraining were recorded, and these both had no influence on the likelihood of human directed canine aggression. Future investigation is required to provide further insight into the training methods utilised to address a wide range of behaviours and the causality of these relationships.

Conclusion

The multivariable logistic regression model in this study shows human-directed aggression is significantly affected by sex of dog, age of dog, attendance at puppy class and presence of another dog aged 0 – 24 months in the household, as compared to dogs with other undesired behaviours. These factors only account for 7 – 10% of the variance between the human-directed aggression population and the control population, but factors such as attendance at puppy classes and numbers of dogs in the household suggest the need for further research. Given that overt aggression is often the last resort a dog will given in response to an escalation of perceived threat and stress (Kendal 2009), the importance of recognising and analysing signalling leading up to aggression cannot be underestimated. Longitudinal studies of factors leading up to, and affecting, human-directed aggression would be beneficial.

References

Amat, M., Manteca, X., Mariotti, V.M., de la Torre, J.L.R., and Fatjo, J. 2009. Aggressive behavior in the English cocker spaniel. Journal of Veterinary Behaviour, 4; 111-117.

Askew, H.R., 1996. Treatment of Behaviour Problems in Dogs and Cats. Blackwell Science, Berlin.

Bamberger, M and Houpt, K.A., 2006. Signalment factors, comorbidity, and trends in behaviour diagnoses in dogs: 1,644 cases (1991 – 2001). Journal of the American Veterinary Medical Association, 229: 1591 – 1601.

Beaver, B.V., 1999. Canine Behavior: A Guide for Veterinarians. Saunders, pp 137 – 199.

Bender, R., and Lange, S., 2001. Adjusting for multiple testing-when and how? Journal of Clinical Epidemiology, 54: 343 – 349.

Bennett, P.C., and Rohlf, V.I., 2007. Owner-companion dog interactions: relationships between demographic variables, potentially problematic behaviours, training engagement and shared activities. Applied Animal Behaviour Science, 102: 65 – 84.

Blackwell, E., Twells, C., Seawright, A., and Casey, R.A., 2008. The relationship between training methods and the occurrence of behaviour problems, as reported by owners, in a population of domestic dogs. Journal of Veterinary Behavior, 3: 207 – 217.

Blackshaw, J.K., 1991. An overview of types of aggressive behaviour in dogs and methods of treatment. Applied Animal Behaviour Science, 30: 351 – 361.

Borchelt, P.L., 1983. Aggressive-behavior of dogs kept as companion animals-classification and influence of sex, reproductive status and breed. Applied Animal Ethology, 10: 45 – 61.

Borchelt, P.L., and Voith, V.L., 1996. Aggressive Behaviour in Dogs and Cats. In: Voith, V.L. and Borchelt, P.L. (eds.) Readings in Companion Animal Behaviour. Veterinary Learning Systems, Trenton, pp. 217 – 229.

Bradshaw, J.W.S., and Casey, R., 2007. Anthropomorphism and anthropocentrism as influences in the quality of life of companion animals. Animal Welfare, 16(S): 149 – 155.

Calkins, C.M., Bensard, D.D., Patrick, D.A., and Karrer, F.M., 2001. Life-threatening dog attacks: a devastating combination of penetrating and blunt injuries. Journal of Pediatric Surgery, 36: 1115 – 1117.

Cameron, D.B., 1997. Canine dominance-associated aggression: concepts, incidence, and treatment in a private behaviour practice. Applied Animal Behaviour Science, 52: 265 – 274.

Casey, R.A., Loftus, B., Bolster, C., Richards, G. and Blackwell, E.J., 2012. Inter-dog aggression in a UK owner survey: prevalence, co-occurrence in different contexts and risk factors. Veterinary Record, 172, 127. doi: 10.1136/vr.100997.

Casey, R.A., Loftus, B., Bolster, C., Richards, G.J., and Blackwell, E., 2013. Human directed aggression in domestic dogs (*Canis familiaris*): Occurrence in different contexts and risk factors. Applied Animal Behaviour Science, 152: 52 – 63.

Chen, S.C., Tang, F.C., Lee, H.S., Yen, C.H., and Lee, M.C., 2000. An epidemiologic study of dog bites amongst postmen in central Taiwan. Chang Gung Medical Journal, 23: 277 – 283.

Cornelissen, J.M.R., and Hopster, H., 2010. Dog bites in the Netherlands: a study of victims, injuries, circumstances and aggressors to support evaluation of breed specific legislation. The Veterinary Journal, 186: 292 – 298.

De Keuster, T., Lamoureux, J., and Kahn, A., 2006. Epidemiology of dog bites: A Belgian experience of canine behaviour and public health concerns. The Veterinary Journal, 172: 482-487.

Duffy, D.L., Hsu, Y., and Serpell, J.A., 2008. Breed differences in canine aggression. Applied Animal Behaviour Science, 114: 441 – 460.

Fatjó, J., Ruíz de la Torre, J.L., Manteca, X., 2006. The epidemiology of behavioural problems in dogs and cats: a survey of veterinary practitioners. Animal Welfare, 15: 179 – 185.

Fatjó, J., Amat, M., Mariotti, V.M, Ruíz de la Torre, J.L., and Manteca, X., 2007. Analysis of 1040 cases of canine aggression in a referral practice in Spain. The Journal of Veterinary Behavior: Clinical Applications and Research, 2: 158 – 165.

Gershman, K., Sacks, J., and Wright, J., 1994. Which dogs bite – a case-control study of risk -factors. Pediatrics, 93: 913 – 917.

Gilchrist, J., Sacks, J.J., White, D., and Kresnow, M.J., 2008. Dog bites: still a problem? Injury prevention, 14: 296 - 301.

Goodloe, L.P., and Borchelt, P.L., 1998. Companion dog temperament traits. Journal of Applied Animal Welfare Science, 1; 303-338.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B, Dohoo, I.R, and Bate, L.A., 2001a. Demographic and aggressive characteristics of dogs in a general veterinary caseload. Applied Animal Behaviour Science, 74: 15 – 28.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B., Dohoo, I.R.A., 2001b. Risk factors for dog bites to owners in a general veterinary caseload. Applied Animal Behaviour Science, 74: 29 – 42.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B., Dohoo, I.R.A., 2001c. A case series of biting dogs: characteristics of the dogs, their behaviour, and their victims, Applied Animal Behaviour Science, 74: 43 – 57.

Herron, M.E., Shofer, F.S., and Reisner, I.R., 2009. Survey of the use and outcome of confrontational and non-confrontational training methods in client-owner dogs showing undesired behaviors. Applied Animal Behaviour Science, 117: 47 – 54.

Hilby, E.F., Rooney, N.J., and Bradshaw, J.W.S., 2004. Dog-training methods: their use, effectiveness and interaction with behaviour and welfare. Animal Welfare, 13(1): 63 – 69.

Horisberger, U., Stärk, K.D.C., Rüfenacht, J., Pillonel, C., and Steiger, S., 2004. The epidemiology of dog bite injuries in Switzerland – characteristics of victims, biting dogs and circumstances. Anthrozoös, 17: 320 – 339.

Hosmer, D.W., and Lemeshow, S., 1989. Applied Logistic Regression. A Wiley-Interscience Publication. John Wiley & Sons, New York.

Hsu, Y., and Sun, L., 2010. Factors associated with aggressive responses in pet dogs. Applied Animal Behaviour Science, 123: 108 – 123.

Jagoe, A., and Serpell, J., 1996. Owner characteristics and interactions, and the prevalence of canine behaviour problems. Applied Animal Behaviour Science, 47: 31 – 42.

Kaskebar, A.V., Garfit, H., Duncan, C., Mehta, B., Davies, K., Narasimhan, G., and Donne, A.J., 2013. Dog bites to the head and neck in children; an increasing problem in the UK. Clinical Otolaryngology, 38: 259 – 262.

Kim, Y.M., El-Aty, A.M.A., Hwang, S.H., and Lee, S.M., 2009. Risk factors of relinquishment regarding canine behaviour problems in South Korea. Berliner and Münchener Tierärtzliche Wochenschrift, 122 (1 - 2): 1 – 7.

Kobelt, A.J., Hemsworth, P.H., Barrett, J.L., and Coleman, G.J., 2003. A survey of dog ownership in suburban Australia – conditions and behaviour problems. Applied Animal Behaviour Science, 82: 137 – 148.

Landsberg, G.M., 1991. The distribution of canine behaviour cases at three behavioural referral practices. Veterinary Medicine, 86: 1011 – 1018.

Landsberg, G., Hunthausen, W., and Ackerman, L., 2003. Canine aggression. In: Handbook of Behaviour Problems of the Dog and Cat, Saunders , London, pp. 129 – 150.

Lund, J., D., Agger, J., F., and Vestergaard, K.S., 1996. Reported behaviour problems in pet dogs in Denmark: age distribution and influence of breed and gender. Preventative Veterinary Medicine, 28: 33 – 48.

Mertens, P.A., 2002. Canine aggression. In: Horwitz, D., Mills, D and Heath, S. (Eds.), BSAVA Manual of Canine and Feline Behavioural Medicine, 1st edition. British Small Animal Veterinary Association, Gloucester, England, pp. 195 – 199.

Messam, L.L.M., Kass, P.H., Chomel, B.B., and Hart, L.A., 2008. The human-canine environment: a risk factor for non-play bites? The Veterinary Journal, 177: 205 – 215.

Michaelazzi, M, Riva, J, Palestrini, C., and Verga, M., 2004. Dog aggression in the present social environment: approach to the problem and operational aspects.

In: Heath, S.E., and Osella, C., (Eds.), Proceedings of the 10th European Congress on Companion Animal Behavioural Medicine, Cremona, pp. 25 – 27.

Morgan, M., and Palmer, J., 2007. Dog bites. British Medical Journal, 334: 413–417.

Newman, J. 2012. Human-directed dog aggression; A systematic review. MSc Philosophy Thesis. University of Liverpool (repository.liv.ac.uk/7753/1/NewmanJen_June2012_7753.pdf)

Ott, S., Schalke, E., von Gaertner, A.M., and Hackbarth, H., 2008. Is there a difference? Comparison of golden retrievers and dogs affected by breed-specific legislation regarding aggressive behavior. The Journal of Veterinary Behavior; Clinical Applications and Research, 3: 134 – 140.

Overall, K.L., 1997. Canine aggression. In: Clinical Behavioral Medicine for Small Animals. Mosby-Year Book, St. Louis, pp. 130 – 143.

Overall, K.L., and Love, M., 2001. Dog bites to humans: demography, epidemiology, injury and risk. Journal of the American Veterinary Medical Association, 218: 1923 – 1934.

O'Sullivan, E.N., Jones, B.R., O'Sullivan, K., and Hanlon, A.J., 2008a. Characteristics of 234 dog bite incidents in Ireland during 2004 and 2005. Veterinary Records, 163: 37 – 42.

O'Sullivan, E.N., Jones, B.R., O'Sullivan, K., and Hanlon, A.J., 2008b. The management and behavioural history of 100 dogs reported for biting a person. Applied Animal Behaviour Science, 114: 149 – 158.

Pérez-Guisado, J., and Muñoz-Serrano, A., 2009. Factors linked to dominance aggression in dogs. Journal of Animal and Veterinary Advances, 8: 336 – 342.

Pfortmuller, C.A., Efeoglou, A., Furrer, H., and Exadaktylos, A. K., 2013. The Scientific World Journal, Sep 24;2013:393176. doi: 10.1155/2013/393176

Pocock, S.J., 1997. Clinical trials with multiple outcomes: a statistical perspective on their design, analysis, and interpretation. Control Clinical Trials 18: 530 – 545.

Podberscek, A.L., and Serpell, J., 1997(a). Environmental influences on the expression of aggressive behaviour in English cocker spaniels. Applied Animal Behaviour Science, 52: 215 – 227.

Podberscek, A.L., and Serpell, J., 1997(b). Aggressive behaviour in English cocker spaniels and the personality of their owners. Veterinary Records, 141: 73 – 76.

Reisner, I.R., Houpt, K.A., and Shofer, F.S., 2005. National survey of owner-directed aggression in English Springer Spaniels. Journal of the American Veterinary Medical Association, 227 (10): 1594 – 1603.

Rosado, B., Garcia-Belenguer, S., Leon, M., and Palacio, J., 2007. Spanish dangerous animals act: effect on the epidemiology of dog bites. Journal of Veterinary behaviour – Clinical Applications and Research, 2: 166 – 174.

Sacks, J.J., Kresnow, M., and Houston, B., 1996. Dog bites: how big a problem? Injury Prevention, 2: 52 – 54.

Sacks, J.J., Ainoedhofer, H., Singer, G., Petnehazy, T., Mayr, J., Kiss, K., and Höllworth, M.E., 2000. Breeds of dogs involved in fatal human attacks in the United States between 1979 and 1998. Journal of the American Veterinary Medical Association, 217: 836 – 840.

Salman, M. D., New Jr., J.G., Scarlett, J.M., Kass, P.H., Ruch-Gallie, R., and Hetts, S. , 1998. Human and animal factors related to relinquishment of dogs and cats in

12 selected animal shelters in the United States. Journal of Applied Animal Welfare Science, 1: 207 – 226.

Shepard, K., 2009. In: Horwitz, D., Mills, D and Heath, S. (Eds.), BSAVA Manual of Canine and Feline Behavioural Medicine, 2nd edition. British Small Animal Veterinary Association, Gloucester, England, pp. 13 – 16.

Svartberg, K., 2006. Breed-typical behaviour in dogs – Historical remnants or recent constructs? Applied Animal Behaviour Science, 96: 293 – 313.

Takeuchi, Y., and Houpt, K.A., 2003. Behavior Genetics. Veterinary Clinics of North America: Small Animal Practice, 33 (2), 345 – 363.

Takeuchi, Y., Ogata, N., Houpt, K.A., and Scarlett, J.M., 2001. Differences in background and outcome of three behaviour problems of dogs. Applied Animal Behaviour Science, 70: 297 – 308.

Van den Berg, L., Schilder, M.B.H., de Vries, H., Leegwater, P.A.J, and van Oost, B.A., 2006. Phenotyping of aggressive behaviour in golden retriever dogs with a questionnaire. Behavior Genetics, 36: 882 – 902.

Weiss, H.B., Friedman, D.I. and Coben, J.H., 1998. Incidence of dog bite injuries treated in emergency departments. Journal of American Medical Association, 279: 51 – 53.

Wright, J.C., 1990. Reported dog bites: are owned and stray dogs different? Anthrozoös, 4: 113 – 119.

Wright, J.C., and Nesselrote, M.S., 1987. Classification of behavioural problems in dogs: distribution of age, breed, sex and reproductive status, 19: 169 – 178.

1. United Kingdom. Dangerous Dogs Act 1991. (65/1991). Enacted 12th August 1991, amended May and October 2014

2 Republic of Ireland. Control of Dogs Act, 1986. 1986. (32/1986). Enacted 17th December 1986

3. Germany. Dangerous Animals Act of Lower Saxony, Germany (GefTVO). 2000. Enacted 5th July 2000